

COMPARISONS OF AQUARIUS MEASUREMENTS OVER OCEANS WITH RADIATIVE TRANSFER MODELS AT L-BAND

E. Dinnat¹, D. Le Vine², S. Abraham³, P. de Mattheis⁴, C. Utiku⁴

1) Chapman University, NASA-GSFC, Greenbelt Rd, Greenbelt, MD20771

2) NASA-GSFC, Greenbelt Rd, Greenbelt, MD20771

3) Wyle Information Systems, LLC, NASA-GSFC, Greenbelt Rd, Greenbelt, MD20771

4) Universities Space Research Association, NASA-GSFC, Greenbelt Rd, Greenbelt, MD20771

1. INTRODUCTION

The Aquarius/SAC-D spacecraft includes three L-band (1.4 GHz) radiometers dedicated to measuring sea surface salinity. It was launched in June 2011 by NASA and CONAE (Argentine space agency). We report detailed comparisons of Aquarius measurements with radiative transfer model predictions. These comparisons are used as part of the initial assessment of Aquarius data and to estimate the radiometer calibration bias and stability. Comparisons are also being performed to assess the performance of models used in the retrieval algorithm for correcting the effect of various sources of geophysical "noise" (e.g. Faraday rotation, surface roughness). Such corrections are critical in bringing the error in retrieved salinity down to the required 0.2 practical salinity unit on monthly global maps at 150 km by 150 km resolution.

2. METHODS

We use a radiative transfer simulator to generate predicted Aquarius measurements that are compared to the actual measurements. The simulator computes the effects of the following processes on the measured signal: 1) emission from Earth surfaces (ocean, land, ice), 2) atmospheric emission and absorption, 3) emission from the Sun, Moon and celestial Sky (received directly through the antenna sidelobes or after reflection/scattering at the Earth surface), 4) Faraday rotation, and 5) convolution of the scene by the antenna gain patterns. Figure 1 (left) illustrates the differences between Aquarius measurements and simulations over ocean only scenes (> 99.9% ocean) during one example orbit. A large constant difference of the order of 4 K can be observed. Once one of the datasets is empirically corrected for this constant bias, both signals are in relatively good agreement (with a rms difference of the order of 0.5 K), illustrating the skills of the model. Fine scale differences remain and these provide tools to assess such issues as inaccuracies in the models or ancillary data. The simulator is currently being used in the

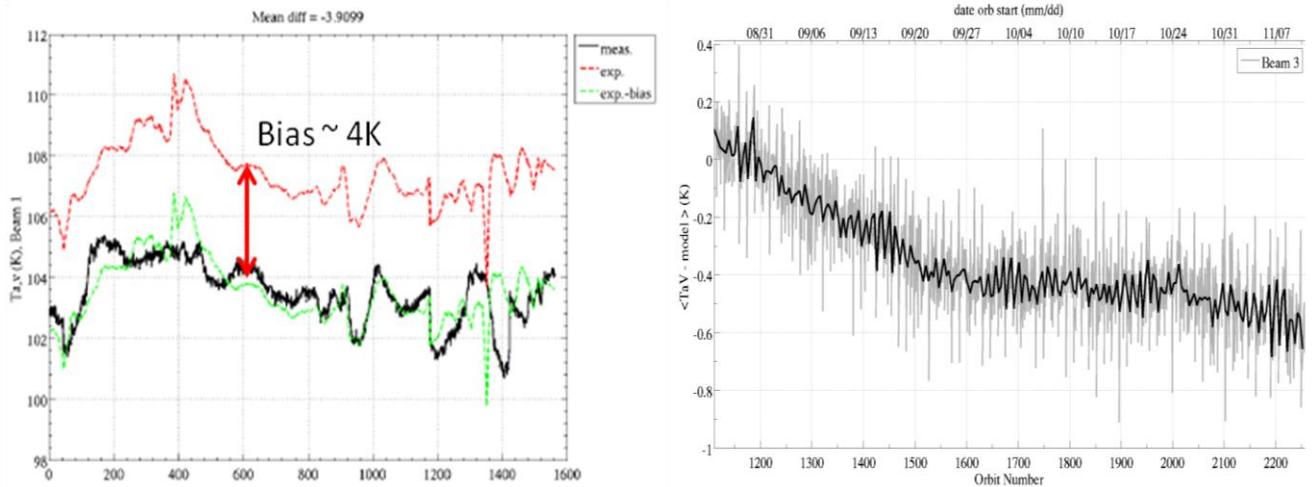


Figure 1: Left: Example of antenna temperature at vertical polarization measured by Aquarius outer beam (black) and simulated (red) during one orbit, over ocean only. The green dashed curve is the simulation corrected for a constant bias in order to minimize the differences with measurements. Right: Temporal evolution of the bias between measurements and simulation after a constant bias has been removed. The grey curve is the bias averaged per orbit, the black curve on top is for a 5 orbits average.

salinity retrieval to correct for various sources of signal at L-band, such as the Faraday rotation, the atmosphere, surface roughness and temperature, and the effects the antenna gain patterns.

3. FIRST RESULTS AND ONGOING ASSESSMENTS

As illustrated by the example in Fig. 1, left, measured antenna temperatures were found systematically lower than the predicted ones for all beams and polarizations. Biases were larger at vertical polarization (from about -2.5K to -3.5K for the three beams) than at horizontal polarization (from about -0.5K to -1.7K). After removing the initial bias averaged over a few days to cover global geophysical conditions, the evolution of the differences data-model over a few months (Fig. 1, right) exhibits a calibration drift of the order of 0.01-0.03K per day for all beams and polarizations. The constant bias calibration is somewhat arbitrary as it depends on the model chosen, hence the correction mixes actual instrument bias and model bias; although it should be noted that biases detected in comparison with the model (on the order of 3 K) are on the order of the pre-launch uncertainty in the instrument calibration. Also, because the calibration drift is measured at global scale, it is unlikely to be due to the model. The drift has actually been identified as being related to a drift in instrument noise diodes. Another approach to assess the radiometers calibration is to look at the cold celestial sky. We analyzed five pseudo cold sky maneuvers (actually orbit adjustment maneuvers, with land and RFI present in the back lobes when a strictly cold sky maneuver would have mostly ocean in the backlobes) to assess the remaining bias at the cold end after the empirical correction over ocean has been performed (Fig. 2).

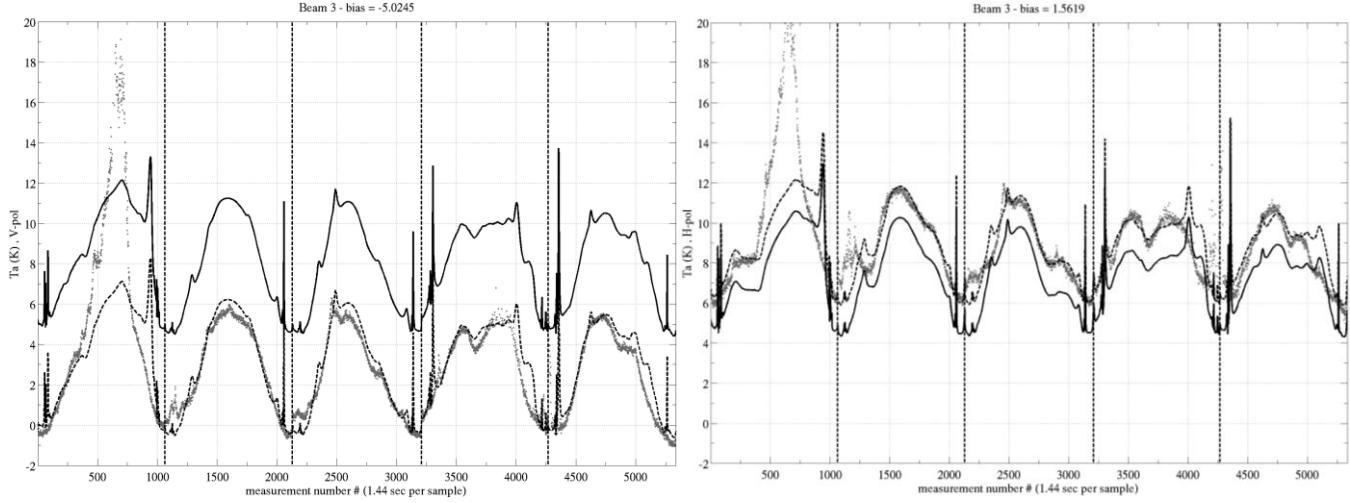


Figure 2: Antenna temperatures during 5 pseudo cold sky maneuvers (separated by vertical dashed lines) measured by Aquarius (dark grey dots) and simulated (black plain line) at (left) vertical polarization and (right) horizontal polarization, after empirical calibration of measurements over oceans. The dashed black curve is the simulations corrected for a constant bias (reported on top of the figure) in order to minimize difference with the data.

The horizontal polarization calibration appears reasonable (considering model uncertainties and how far from the ocean range of temperatures these measurements are performed), with biases of 0.4K, -0.2K and 1.2 K for the three beams. However, the vertical polarization calibration appears problematic: biases for all beams are -1.6 K, -3.1 K and -5.4 K, with recalibrated measurements being less than the cosmic background of 2.7 K, and even slightly negative, at a few locations.

Figure 3, left, reports comparisons of Faraday rotation angle retrieved from Aquarius measurements with simulated ones. There are significant beam dependent differences, of a few degrees over ocean, and much larger and variable over land and ice. The retrieval of Faraday angle involves first correcting the measurements for the effect of antenna patterns. The discrepancy in Faraday angles is identified as being caused by an incorrect antenna gain pattern correction. As shown in Fig. 3, middle, the forward model from which the antenna pattern correction is derived predicts too large of a third Stokes parameter compared to the measured one. This is caused by too large of a crosspol gain in the gain pattern models that were derived from measurements using a scale model of the spacecraft. Once the crosspol terms are set to zero (in better agreement with a different set of gain patterns obtained from numerical simulations), the differences in third Stokes parameters become much smaller, more consistent over land, ice and ocean and across beams (Fig. 3, right). Further comparisons between Faraday angles retrieved from Aquarius data and those computed from the total electron content derived from JASON altimeter are underway and will be presented.

Initial assessments of the impact of roughness on the brightness temperature (Fig. 4) lead to noticeable differences with models (not shown). The wind dependence is less linear than model predictions, and the dependence on

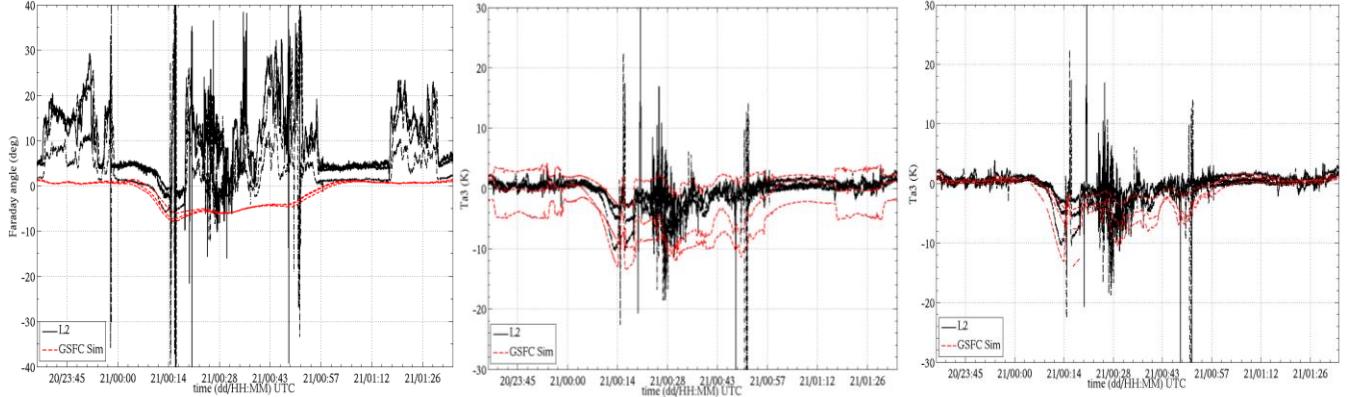


Figure 3: Left: Faraday rotation angle retrieved from the Aquarius level 2 data (black) and simulated (red) during one orbit, for all three beams. Middle: Third Stokes parameter measured (black) and simulated (red). Right: Same as Middle plot, after correction of gain pattern model.

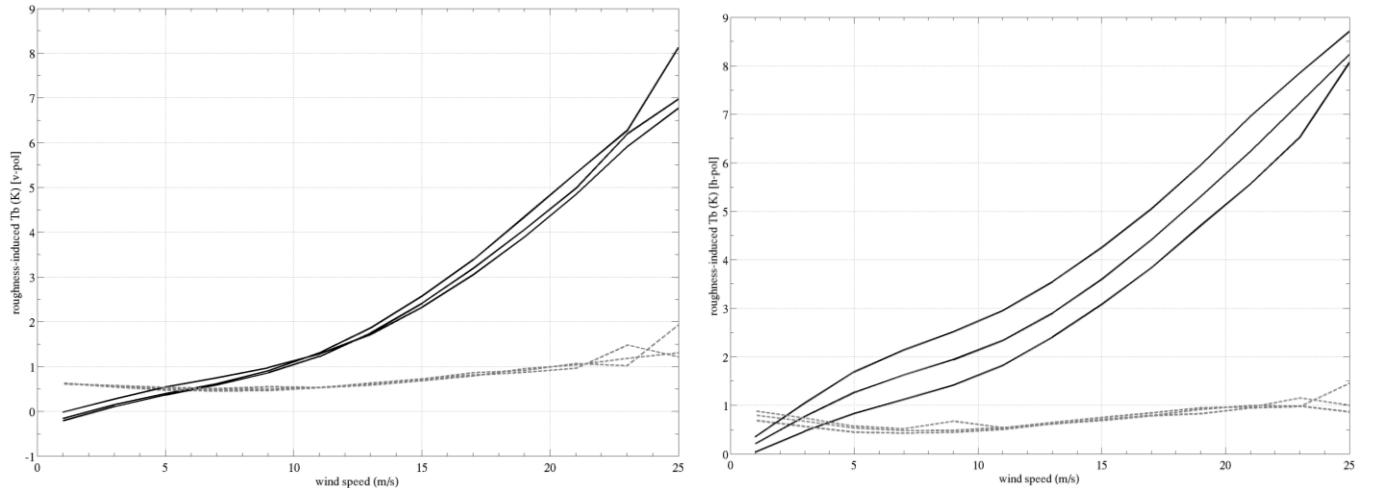


Figure 4: roughness-induced brightness temperature measured by Aquarius versus wind speed for all three beams (black curves) in (left) vertical and (right) horizontal polarizations. The curves are computed as the mean of the Aquarius data inside 2 m/s wide bins, with the grey curves at the bottom reporting the standard deviation of the data inside each bin. Data used for these plot are from August 25, 2011 to Jan 01, 2012.

incidence angle at horizontal polarization is larger. Further model/data comparisons are underway in order to assess the discrepancies, and derive an accurate model for the dependence of the signal on surface roughness as a function of wind speed, wind direction, significant wave height and/or slope variance.

4. CONCLUSIONS

We will report comparisons of the Aquarius data with simulator predictions to assess the calibration of the data and the performances of the models for correcting impacts of sources such as sea surface roughness, the celestial Sky and the Sun glint. Improved knowledge on the radiative transfer models at L-band will not only lead to better salinity retrieved from Aquarius data, it should also be beneficial for SMOS or the upcoming SMAP mission.